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A STATISTICAL STUDY IN CORRELATION OF EFFICIENCY IN SECONDARY MATHEMATICS AND EFFICIENCY IN OTHER HIGH SCHOOL BRANCHES.

By Nelle L. Ingels.

It is the purpose of this paper to record the results obtained from an investigation concerning the correlation of efficiency—(1) in the study of mathematics and history, (2) in the study of mathematics and foreign language, and (3) in the study of history and foreign language. A similar investigation was made several years ago by Prof. H. L. Rietz and Miss Imogene Shade, "On the Correlation of Efficiency in Mathematics and Efficiency in Other Branches," in the University of Illinois.*

What is the probability that a student who does good work in one subject will do good work in another subject? This question has been a much discussed one. Some hold that the student is "born short" along certain lines and "born long" or strong along other lines.

A statistical study of this question shows that the correlation coefficient is very high. While it is true that some students are very efficient in the study of some subject or subjects and very poor in others, they are the exceptional and isolated cases; they are not the average or the rule.

The sources of information were the records of Greenville High School and the records of the Preparatory Department of Greenville College from 1908 to 1917.

In selecting the data, only those cases in which the subject had been carried simultaneously were considered, and in each case each subject had been carried for at least one year. The year's average was used in all cases.

It seems reasonable to suppose that the general conditions will be most nearly the same if the above methods be used in

* University of Illinois Bulletin, Vol. 3, No. 1.

selecting the data. It is not assumed that all teachers grade accurately; but, that in the long run, the teachers in general, are fair and accurate in their estimate of the student's value in grading.

While the sample in each case is small, it seems reasonable to believe that it is a random sample and that, with a larger popula-

TABLE I.

$$r = \frac{1}{\sigma_r \sigma_c}\left(\frac{\Sigma D_r D_c}{u} = c_r c_c\right) \pm E = 0.59 \pm 002$$

$$E = \pm \frac{0.6745(1 - r^2)}{\sqrt{n}}$$

History \ Mathematics	75	80	85	90	95	100	f	$v-g$	$f\cdot(v-g)$	$f\cdot(v-g)^2$	$D_r D_c$
75	15	15	5	1		6	36	−10	−360	3600	2200
80	15	33	31	9	2		90	− 5	−450	2250	1250
85	9	32	32	13	10		96	0	−810		
90	6	14	17	50	19	1	107	5	535	2675	1625
95		5	12	20	29	6	72	10	720	7200	4550
100					2		2	15	30	450	300
f	45	99	97	93	62	7	403		1285	403)16175	403)9925
									−810	40.1365	$\frac{\Sigma D_r D_c}{n} = 24.6279$
$v-g$	−10	5	0	5	10	15			403)475	$c_c^2 = 1.3893$	
	−1								$c_c = 1.1787$	$\sigma_c^2 = 38.7473$	$c_r c_c = 0.7165$
										$\sigma_3 = 6.2247$	23.9114
$f\cdot(v-g)$	−450	−495	−945	465	620	105	1190	−945	403)245	$c_r = 0.6079$	
$f\cdot(v-g)^2$	4500	2475		2325	6200	1575	403)17075	42.3697	$c_r^2 = 0.3694$	$\sigma_r^2 = 42.0003$	$\sigma_r = 6.4807$

$$r = \frac{23.9114}{6.2247 \times 6.4807} \pm E$$

$$r = 0.592 \pm 0.022$$

tion the deviation from the results obtained, will be the deviation due to random sampling. It seems reasonable to believe that the training through the eighth grade is more nearly uniform in all schools than the training in all high schools, because of general use of the course of study of the state, and because of the county examinations for the eighth grade graduation. It is, therefore, reasonable to expect a slightly higher degree of

correlation in this study because of the more nearly uniform training than was found by Prof. Henry L. Rietz* and Miss Imogene Shade in the correlation of efficiency in mathematics and efficiency in other branches in the University of Illinois.

TABLE II.

$r = 0.53 \pm 0.02.$

$r = 0.53 \pm 0.02$

Foreign Language \ Mathematics	75	80	85	90	95	100	f	$v-g$	$f\cdot(v-g)$	$f\cdot(v-g)^2$	D_rD_c
75	12	25	12	4			53	−10	− 530	5300	2250
80	18	48	33	15	3	1	118	− 5	− 590	2950	1500
85	17	40	42	33	8		140	0	−1120		
90	7	12	30	43	26		118	5	590	2950	1725
95	3	1	3	15	34	1	57	10	570	5700	3050
100				2	2		4	15	60	900	450
f	57	126	120	112	73	2	490		1220	490)17800	490)9875
									−1120	36.3267	$\frac{\Sigma D_rD_c}{n} = 20.153$
$v-g$	−10	−5	0	5	10	15			490) 100	$c_c^2 = 0.0416$	
									$c_c = 0.204$	$\sigma_c^2 = 36.285$	$c_rc_c = 0.050$
										$\sigma_c^2 = 6.024$	20.103
$f\cdot(v-g)$	−570	−630	−1200	560	730	30	1320		−1200	490) 120	$c_r = 0.245$
$f\cdot(v-g)^2$	5700	3150		2800	7300	450	490)19400		39.591	$c_r^2 = 0.060$	$\sigma_r^2 = 39.531$
											$\sigma_r = 6.287$

$$r = \frac{20.103}{6.287 \times 6.027} \pm 0.021$$

$$r = 0.530 \pm 0.021$$

In tabulating the results a double entry table known as a correlation table was constructed. The grades were tabulated in groups which differ by five (5). The grades for example, in the 90-class are greater than 87.5 and less than or equal to 92.5

$$87.5 < 90 \leqq 92.5.$$

Table II presents the classification of 490 induividuals who studied mathematics and history at the same time and had at least one year's grade in each subject. Any number, say for example, 19, in column headed 95 and the row with 90 at the

* University of Illinois Bulletin, Vol. 3, No. 1.

left, indicates that there were nineteen students who were in the 95-class in mathematics and 90-class in history.

Table II preesnts the classification of 490 individuals who have studied mathematics and foreign language at the same time and have at least a year's grade in each subject.

Table III presents 426 individuals who have studied history and foreign language simultaneously for at least one year and have a grade in each.

TABLE III.

$r = 0.555 \pm 0.022.$

Foreign Language \ History	75	80	85	90	95	100	f	$v-g$	$f.(-v)$	$f.(v-g)^2$	D_rD_c
75	16	14	12	3			45	−10	−450	4500	2150
80	13	37	27	17	3		97	− 5	−485	2425	1000
85	7	29	36	40	16		128	0	−935		
90	1	12	23	43	20		105	5	525	2625	1725
95		4	3	13	28	2	50	10	500	5000	3550
100					1		1	15	15	225	150
f	37	37	197	116	68	2	426		1040	426)14775	426)8575
									−935	34.683	$\frac{\Sigma D_rD_c}{D} = 20.129$
									426) 105	$c_c^2 = 0.061$	
									$c_c = 0.2464$	$\sigma_c^2 = 34.622$	$c_rc_c - 0.255$
										$\sigma_c = 5.884$	19.874
$v-g$	−10	− 5	0	5	10	15					
$f.(v-g)$	−370	−480	−850	580	680	30	1290				
							−850				
							426)440				
							$c_r = 1.0328$				
$f.(v-g)^2$	3700	2400		2900	6800	450	426)16250				
							38.146				
							$c_r^2 = 1.067$				
							$\sigma_r^2 = 37.079$				
							$\sigma_r = 6.089$				

$$r - \frac{19.875}{5.884 \times 6.089} \pm E$$

$$r - 0.555 \pm 0.022$$

The methods used are essentially those of Karl Pearson and Francis Galton. The theory of correlation may be found in any scientific treatment of the subjects.*

The correlation coefficient r always lies between plus one and minus one.

$$1 \geqq r \geqq -1.$$

If $r = +1$ and a grade in one subject is given, the grade in

* G. Udny Yule, Introduction to the Theory of Statistics, pp. 157–209.

the other is determined; that is, if $r = +1$ and a student receives a high grade in one subject he will receive a high grade in the subject.

If $r = -1$ and a grade is given in one subject, the grade in the other is likewise determined; that is, if $r = -1$ for mathematics and foreign language and the student received a high grade in mathematics, he will, necessarily, receive a low grade in foreign language, and vice versa.

If $r = 0$, there is independence. It simply means that if $r = 0$, and a student receives a high mark in one branch under consideration, the wager is even as to whether he receive a high mark or a low mark in the other subject.

In each case the correlation coefficient is greater than $+0.5$

$$r > 0.5.$$

We may show by comparison how high our correlation coefficients really are. Karl Pearson in his "Grammar of Science," page 458, gives the correlation coefficient of inheritance of stature of father and son to be

$$r = 0.396$$

and the stature of brother and brother to be

$$r = 0.391.$$

From this study it seems that we are justified in saying that there is a very high degree of correlation in efficiency in the study of mathematics and certain other secondary subjects.

In conclusion, we may say the results given by quantitative analysis differ widely from those obtained from impressions, which are formed, too often, from isolated cases.

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